Measuring Contrast Sensitivity Using the M&S Smart System II versus the Pelli-Robson Chart

Contrast sensitivity (CS) refers to the ability of the visual system to detect differences in luminance (i.e., brightness) between an object and its background.[1] Assessment of CS provides valuable information in the early detection and monitoring of ocular diseases, as well as evaluating the impact of therapy.[2] The most widely used clinical spatial CS test is the Pelli-Robson chart (Clement Clarke International, Essex, UK).[3] Several factors may influence the CS threshold measured. First, although the recommended luminance is 85 candelas/m^2 (range, 60−120), maintaining consistent luminance across the entire chart can be difficult. Overhead lighting in most examination rooms illuminates preferentially the top portion of the chart, and decreases nonuniformly toward the lower portion. In addition, patients tested in different examination rooms with different light fixtures may exhibit some variation in threshold measurement. Second, the Pelli-Robson chart fades over time with exposure, with a manufacturer-recommended expiry of 7 years. Variation and inaccuracy may occur when comparing measurements using charts of different ages. Third, the chart has only 2 versions with different triplets of optotypes. Patients may recall letters with frequent use, especially those letters that are found around their threshold.

The M&S Smart System II (MSSS-II; M&S Technologies Inc, Niles, IL) includes a computer-generated, letter-based CS test. The luminance of the liquid crystal display (LCD) screen can be adjusted to recommended level of 85 candelas/m^2 using the built-in control and can be monitored for any changes using an external light meter or luminance probe. The testable contrast ranges from 0.0 to 2.3 log units (similar to the Pelli-Robson chart), with each level corresponding to a change of 0.1 log units. Unlike the Pelli-Robson chart, the letters are not arranged in triplets of equal contrast. Instead, a single Sloan letter is displayed randomly in the center of the screen for any given contrast level. The keypad is used by the examiner to access the CS test, to choose randomization options, and to increase or decrease the contrast level of each letter. The system offers several advantages over the Pelli-Robson chart. The test is conducted in a dark room, thereby avoiding issues related to variation in room illumination. The system can be calibrated for various viewing distances (1.8−6.7 m) and does not require recalibration to account for the lighting environment at each testing distance. Furthermore, presentation of random letters prevents patients from memorizing the letters (Table 1, available at http://aaojournal.org). Currently, there are no published data on the validity or reliability of CS testing using the MSSS-II. We compared the MSSS-II with the Pelli-Robson chart as a clinical test for measuring CS in a large population.

Testing was performed on 134 adults and children (262 eyes). The mean age (± standard deviation) was 19.5±14.9 years (range, 5−69 years; 78 females). There were 66 eyes from 33 visually normal participants (mean age, 29.4±15.7 years; range, 5−56; 23 females; visual acuity, 20/15−20/25) and 196 eyes from 101 patients (mean age, 16.3±13.2 years; range, 6−69; 55 females; visual acuity, 20/20−20/400). The ophthalmic diagnoses included glaucoma, diabetic retinopathy, macular drusen, retinitis pigmentosa, optic neuritis, idiopathic intracranial hypertension, optic glioma, and amblyopia. Six eyes with visual acuity of ≤20/200 were excluded. Participants who were not able to read a standard Early Treatment of Diabetic Retinopahty Study (ETDRS) letter chart and those with a prior history of refractive surgery were also excluded. The study was approved by the Research Ethics Board at The Hospital for Sick Children and all protocols adhered to the guidelines of the Declaration of Helsinki. Informed consent was obtained from each participant.

Participants were tested using the MSSS-II and the Pelli-Robson chart in random order during monocular viewing. The MSSS-II optotype size of 1.5 logarithm of the minimum angle of resolution at a testing distance of 4 m was chosen to match the visual angle subtended by the letters presented on the Pelli-Robson chart at 1 m, representing a spatial frequency of 1 cycle per degree for both distances. Participants were tested with the Pelli-Robson chart with each letter being scored individually and assigned a score of 0.05 for each correct response.[4] For the MSSS-II, participants were asked to name the letter that was displayed in the center of the screen. The experimenter then increased or decreased the contrast level based on the previous response. A single Sloan letter was displayed for each contrast level starting at 100% contrast. Once the participant approached their threshold, as determined by any hesitation in response or error in letter identification, randomly selected Sloan letters were presented 2 more times at the same contrast level and the participant was required to identify 2 of the 3 letters per contrast level correctly before the contrast threshold was finalized. The outcome measure was the agreement between MSSS-II and Pelli-Robson.

Bland−Altman analysis[5] demonstrated that the MSSS-II test and Pelli-Robson chart show comparable CS values for both visually normal participants and patients (Fig 1; available at http://aaojournal.org). For visually normal participants (n = 66 eyes), mean CS was 1.67±0.12 log units with MSSS-II, and 1.64±0.04 log units with the Pelli-Robson chart. For patients (n = 196 eyes), mean CS was 1.44±0.29 log units with the MSSS-II, and 1.48±0.28 log units with the Pelli-Robson chart. The mean CS difference detected between the 2 testing methods was minimal: 0.03±0.12 log units (95% confidence interval of limits of agreement, −0.20 to 0.26 log units) for visually normal participants and −0.04±0.12 log units (95% confidence interval of limits of agreement, −0.28 to 0.19 log units) for patients. This variation may be due to the minimal differences in the log progression of the 2 charts (0.10 log units between CS levels for MSSS-II and 0.15 log units for Pelli-Robson). The testing time with the MSSS-II system was shorter because participants were screened with only 1 letter at a high contrast level, and the contrast level was decreased immediately if they identified the single letter with ease. This differed from using the Pelli-Robson chart, which required the participants to read all 3 letters in the triplet for every contrast level.

In conclusion, the close agreement of CS thresholds suggests that the updated version of MSSS-II, when carefully calibrated, can

be used as an alternative method to the Pelli-Robson chart in the measurement of CS in a wide variety of ophthalmic conditions, in both adults and children.

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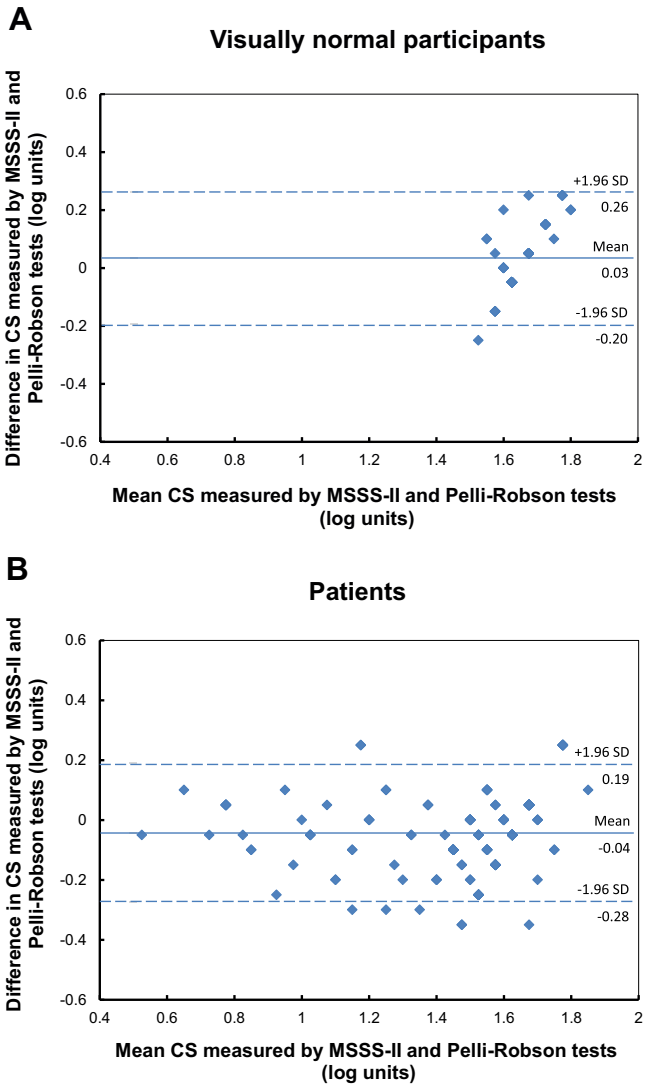

Figure 1. Bland-Altman plots comparing the M&S Smart System II (MSSS-II) and the Pelli-Robson chart for (**A**) visually normal participants and (**B**) patients. CS = contrast sensitivity.

Table 1. Features and Specifications of M&S Smart System II and Pelli-Robson Chart

Feature	M&S Smart System II	Pelli-Robson Chart
Viewing distance	Wall mounted at 1–6.7 m	Wall mounted at 1 or 3 m
CS range (log units)	0.0–2.3	0.0–2.25
Unit decrement (log units)	0.1	$(1/\sqrt{2})$ 0.15 per triplet
Source of illumination	Intrinsic (monitor configuration)	Extrinsic (overhead lighting)
Setup	Calibration is not challenging, only requiring monitor configuration to set appropriate luminance	Calibration may be challenging depending on the configuration of ambient lighting
Durability	Software transferable to new computer/display	Chart may fade over time requiring replacement
Expiration	No expiration	7 years
Other considerations	Built-in visual acuity and CS tests provide convenience and configuration flexibility	More affordable and portable; requires less space

CS = contrast sensitivity.